AF OPPORTUNITIES FOR BASIC RESEARCH

19 April 2006

Col Jeff Turcotte

Deputy Director and Commander

Air Force Office of Scientific Research

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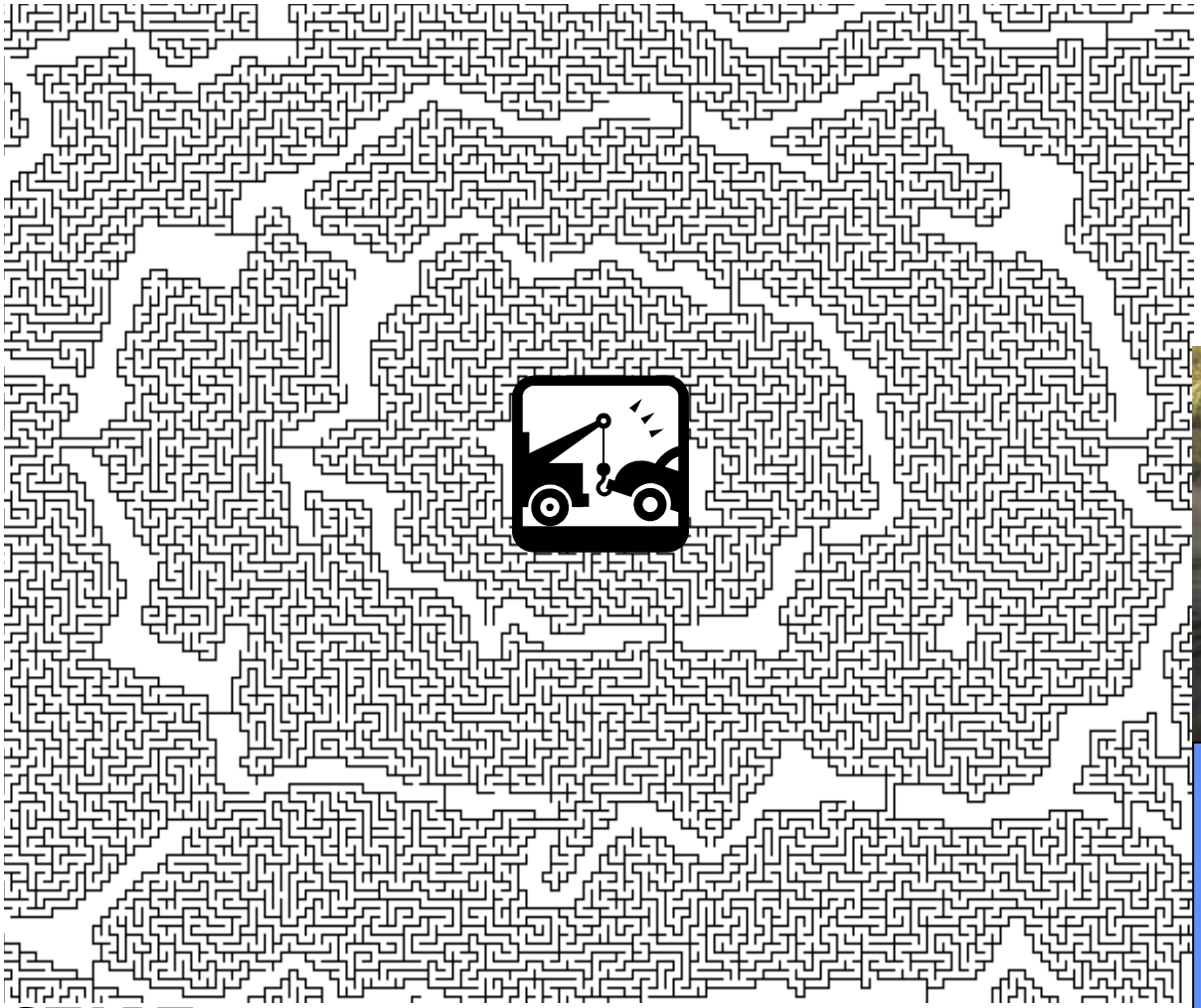
BASIC RESEARCH INVESTMENT

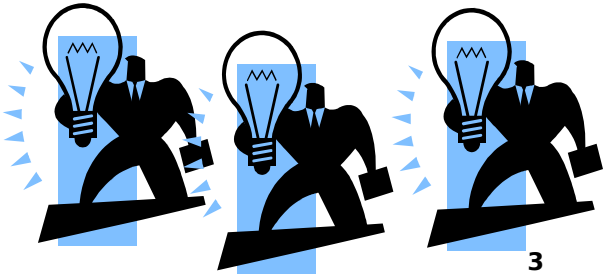
- **Core budget can only be used for basic research**
  - **Definition: systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards process or products in mind**
- **Invest in all areas that might contribute to AF missions**
- **Example: We know Hydrazine is hypergolic but we don't know why**
  - **Who cares, it works?**
  - **Understanding how it works may lead to additional, perhaps friendlier, hypergolic fuels**

Discovery & Innovation Process



DISCOVERY

INNOVATIONS



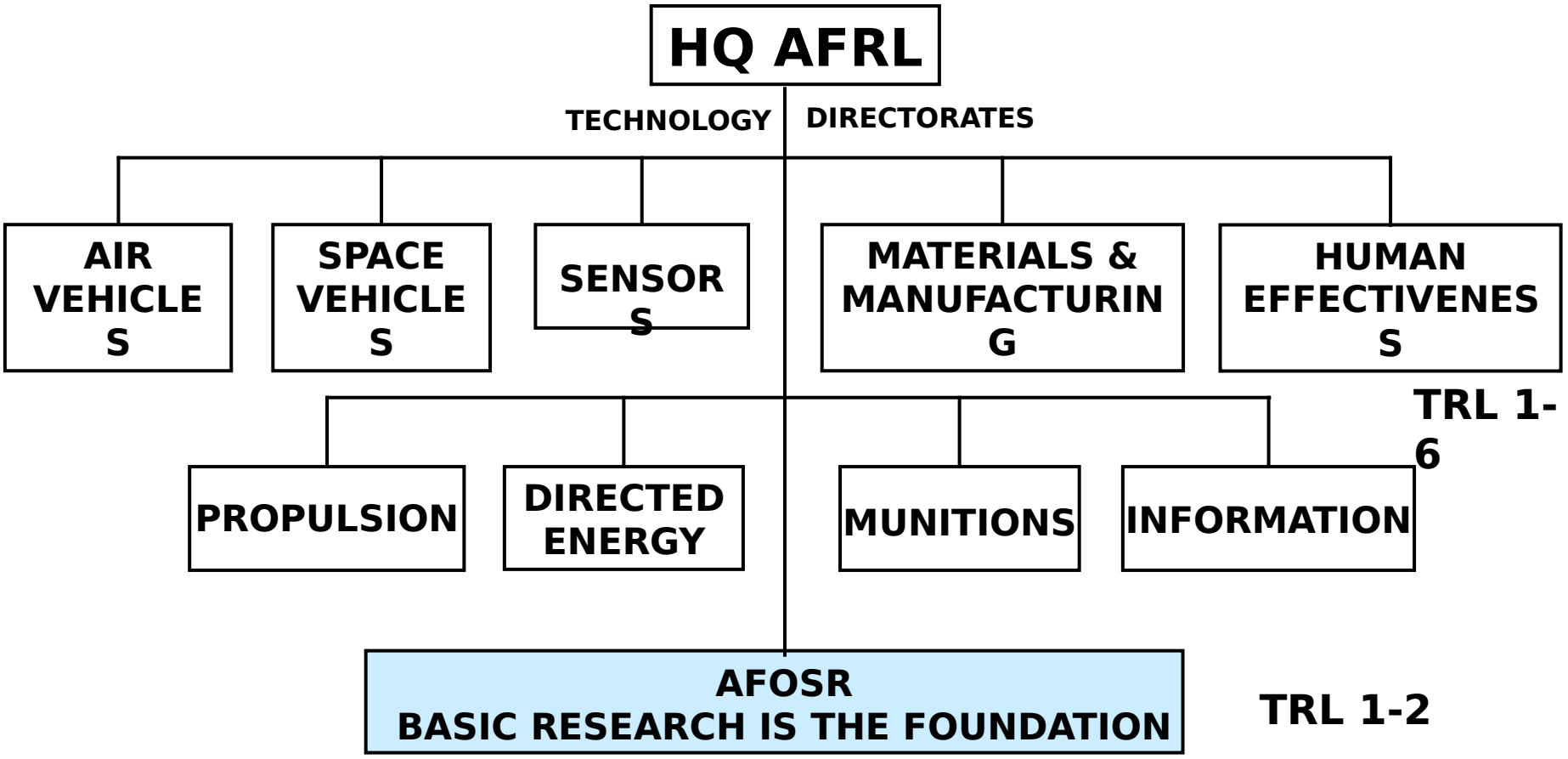
OUTLINE

- AFOSR Overview
- Current initiatives and examples
- Collaborations
- Programs and processes
- Summary

AFOSR Leadership Roles

- **Foster Revolutionary Basic Research for Air Force Needs**
  - 728 extramural research grants at 211 universities
  - 194 intramural research projects at Air Force laboratories
  - 133 STTR small business - university contracts
  - 368 transitions to DOD and industry
- **Build Relationships with Leading Researchers – Here and Abroad**
  - 79 summer faculty; 40 postdocs at AFRL
  - 264 short-term foreign visitors; 37 personnel exchanges
  - 58 technical workshops; 205 conferences sponsored
  - Liaison Offices in Europe and Asia
- **Educate Tomorrow's Scientists and Engineers**
  - About 2000 post-docs and grad students on research grants
  - 430 National Defense Science & Engineering Fellowships

AFOSR Within the AF Research Lab



AFOSR is the Sole Manager of AF Basic Research Funds

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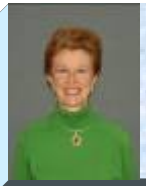

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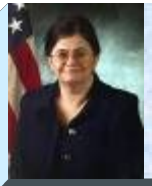

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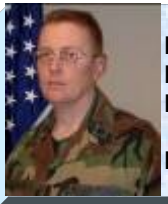

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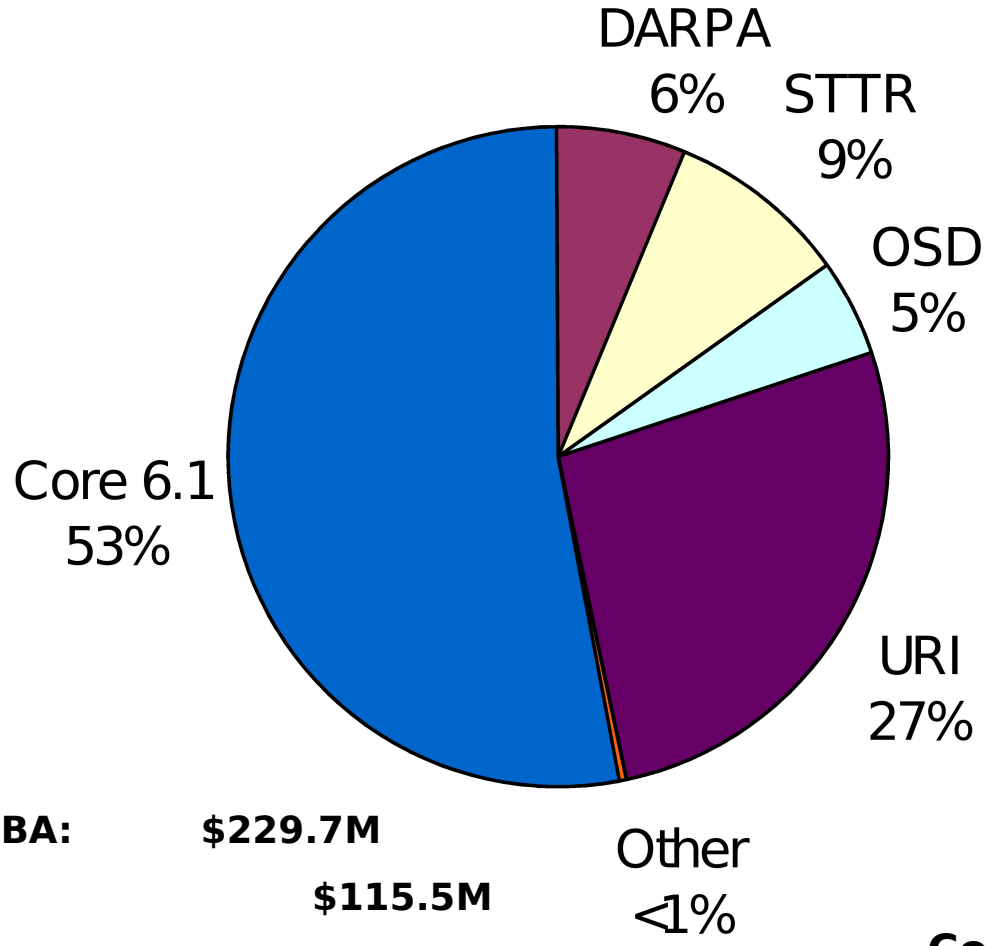
AFOSR
FY05 Budget Authority (BA)



FY05 Core 6.1 BA: **$229.7M**

FY05 URI BA: **$115.5M**

FY05 External Funding: **$88.1M**

Total AFOSR FY05: **$433.3M**

Core funds after taxes

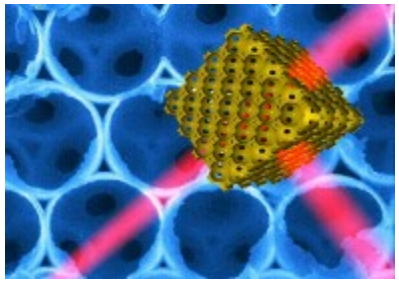
FY06 **$201M**

FY07 **$224M**

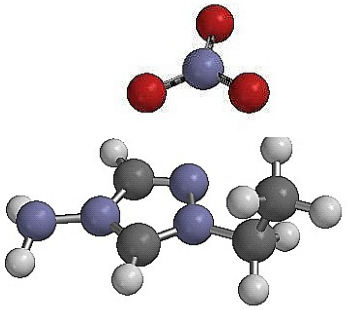
AFOSR Research Areas

Aerospace and Materials Sciences

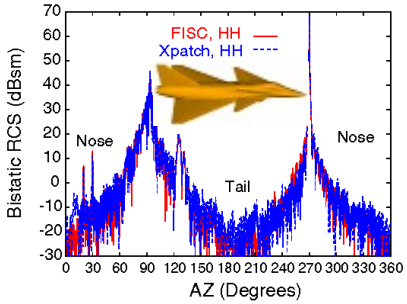
Physics and Electronics



Chemistry and Life Sciences



Mathematics and Information Sciences



Sub-thrusts

- **Solid Mechanics and Structures**
- **Materials**
- **Fluid Mechanics**
- **Propulsion**

- **Physics**
- **Electronics**
- **Space Sciences**

- **Chemistry**
- **Bio Sciences**
- **Human Performance**

- **Info Sciences**
- **Computing Sciences**
- **Mathematics**

Areas of enhanced emphasis:

- **Information Sciences**
- **Mixed-Initiative Decision Making**
- **Adversarial Behavior Modeling**

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Vision for AF IS&T Research: Team-Focused Network-Enabled Systems

Human-system interactions

Goal: Mixed initiative reasoning and decision support

Information management and integration

Goal: Processing & managing of semi-structured content

Software

Goal: Understand what to build, ensure predictability, evolve in the field

Networks & communications

Goal: Assure connectivity

Distributed research & experimentation environments

Multi-UAV control

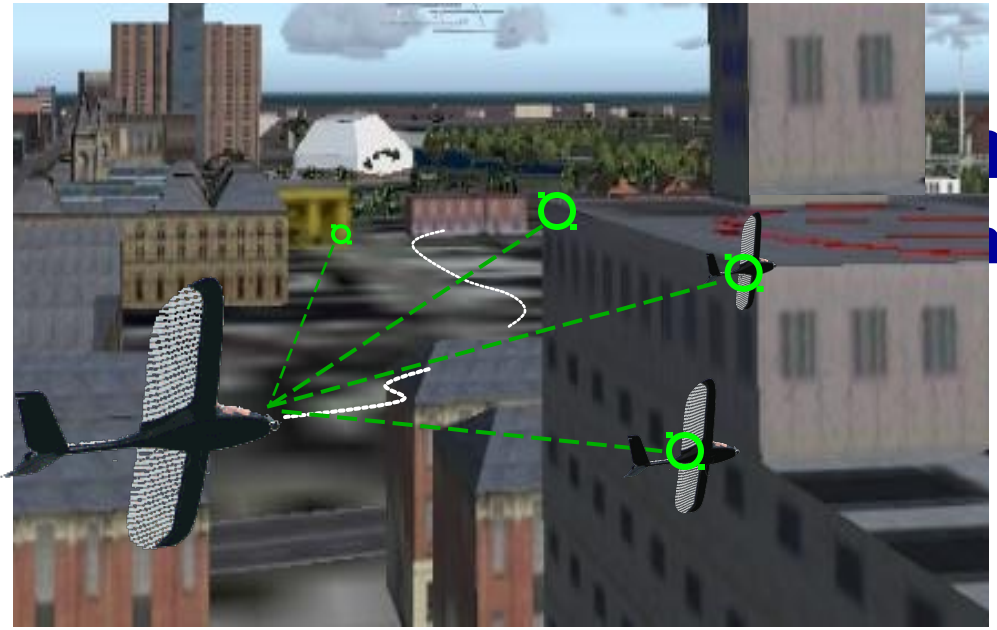
C2 for mixed manned & unmanned operations

Mixed reality training environments

Beyond AOC automated

Grand Challenge Problems

Agile Autonomy for MAVs



Motivation

- Hidden, Occluded Targets
- Target Uncertainty, Mobility
- Stealth, Covert Operation

➔ ***Operation in Confined Airspace***

- Collision Avoidance
- Datalink Dropout
- Situational Awareness

Goal: Operation in Close Proximity to Terrain, Structures

Inspiration from Biology?

Technologies

Aerodynamic Agility

- Exploit Unsteady Aerodynamics
- Agile Airframe Control Concepts

Guidance Agility

- Wide Field-of-Regard Sensing
- Autonomous Imaging

Guidance

Active vision control systems

- **Time-sensitive operation in confined airspace requires aerodynamic agility**
- **Aerodynamic agility in confined airspace requires guidance agility**

Mixed-Initiative Decision Making

- Describe quantitatively how humans process information to learn, recognize, assess, and make decisions about events occurring in dynamic environments
- Develop quantitative models and methods to improve understanding of
  - Multisensory perceptual integration
  - Cognitive and perceptual factors in the acquisition of complex skills, including motor skills
  - Individual and team decision-making
  - Fundamental constraints of attention and memory on human performance
- Ability to identify and quantify the individual attributes that determine or constrain human performance, especially in complex information-processing environments

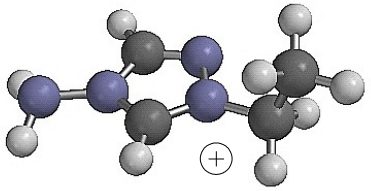
Adversarial Decision Modeling

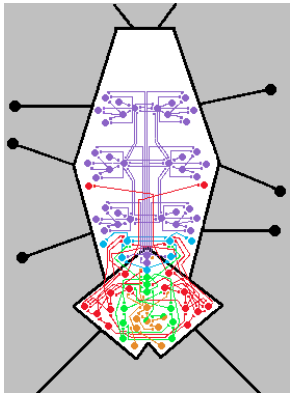
- **Modeling cultural influences on attitudes and behaviors of regional factions**
  - **Determine critical dimensions of culture**
  - **Discover how cultures shape attitudes and behavior**
  - **Model factional dynamics under influence**
- **Influence operations training aids**
- **Decision making in adversarial domains**

Coordinated with informal multi-agency working group

Improved Fuel Efficiency and Alternative Energy

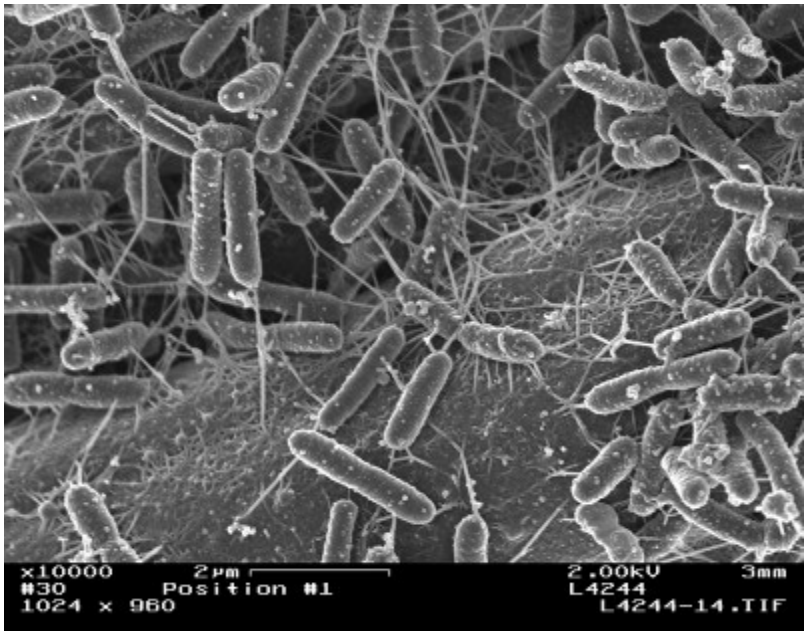
- **Alternative Fuels Combustion Simulation:** Tools to assess the effects of fuel properties on propulsion system performance
- **Plasma Enhanced Combustion**: Short duration corona discharges for improved ignition characteristics in hydrocarbon-air mixtures
- **Trapped Vortex/Ultra Compact Combustors:** Improved efficiencies and emission profiles compared to conventional combustors
- **Solar Cells:** Lighter, more-efficient solar cells for power generation in space
- **Drag Reduction:** Laminar flow control to reduce drag friction and active flow control for optimized aerodynamics
- **Novel Energetic Materials:** New materials (ionic liquids, strained-ring hydrocarbons, polynitrogen compounds) with higher-energy densities, lower volatilities, and other improved properties
- **High Temperature Materials:** New materials to allow engines to operate at higher temperatures
- **Biofuel Cells:** Utilization of enzyme/microbial fuel cells to power micro air vehicles with flexible fuels sources from the environment
- **Bio-hydrogen:** Production of hydrogen from photosynthetic microbes and sunlight
- **Fuels Toxicology:** Determination of biological effects and damage mechanisms to enable the development of safer fuels





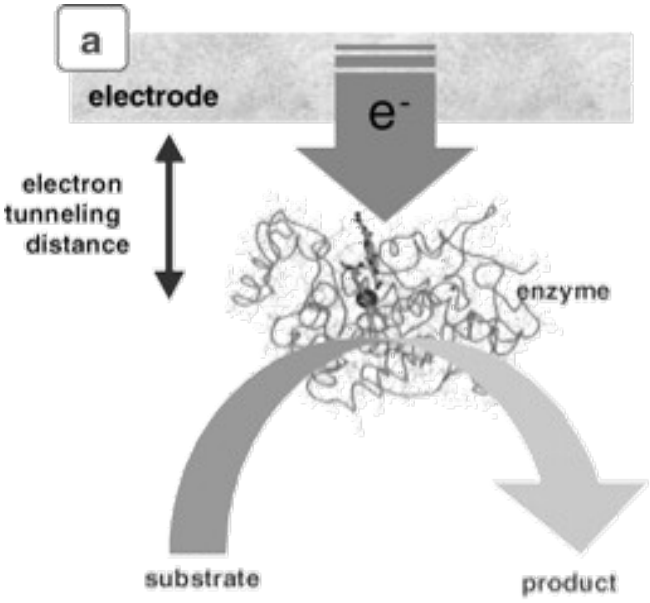
Bioengineering for Compact Power

GOAL: Understand & control electron transfer using biological systems



***Shewanella oneidensis* strain MR-1 cultivated on a graphite fiber electrode**

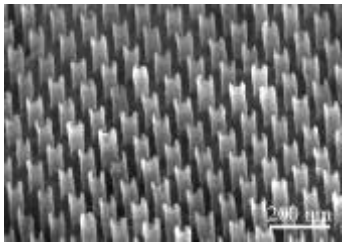
Microbial approach
Ken Nealson - USC



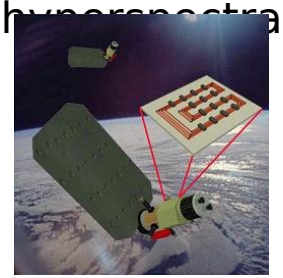
Understanding direct electron transfer to and from electrode surfaces

Enzymatic approach
Plamen Atanassov - UNM

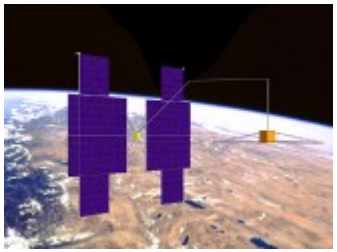
AFRL Nanotechnology Initiative
(Added in FY2006PB)



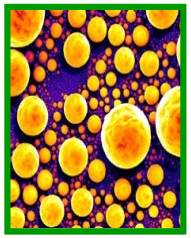
Nanoelectronics: Multispectral Detector Arrays: Explore techniques to control growth of self-assembled quantum structures, connections to the structures, and combinations of both, which will lead to detectors for multispectral and hyperspectral image processing.



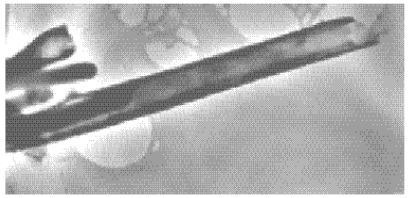
Nanoelectronics: Chip Scale Optical Networks: Forward-looking architectural effort that seeks to develop new concepts in the design, operation, employment, and overall functioning of military platform networks.



Nanoelectronics: Compact Power for Space: Increase specific power for solar arrays, fuel cells, and power storage systems for high power space platforms.



Nanoenergetics: Enable the development of higher performance, less-sensitive nanoscale energetic materials for applications in munitions and propulsion.



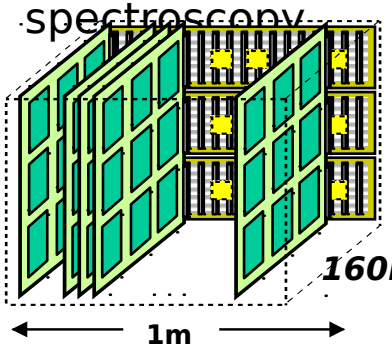
Nanomaterials for Structures: Establish nanomaterial and nanocomposite systems that will enable reduced system weight or size, increased operational lifetime, and multifunctional performance of load-bearing aerospace structures.

PHOTONICS and NANOTECHNOLOGY

(nano-optical circuits)

Microcavities EIT PBG/PC Quantum Dots
Plasmonics
Nanocrystals/particles QC optical
methods
Refractive Index Engineering Dispersion
Engineering

nanometer
scale... The control and
manipulation of light
on this scale offers new
approaches to photonic
devices, as well as
microscopy and
spectroscopy



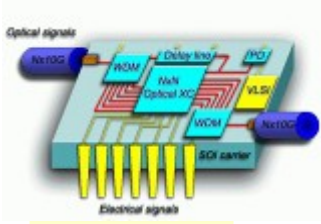
Devices
Phenomena
Tools

Silicon Photonics

Electrical power consumption & dissipation
Achieving greater speed (>10GHz) Interconnects
Novel Computing

The combination of Nanofabrication & Photonics:
Nanofabrication allows for the development of devices at the nanometer level. Photonics allow for the controlling of photons, or light, for telecommu

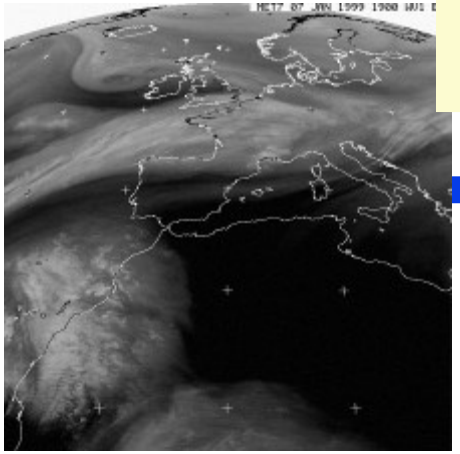
Terabits /s



- Scalable; - High Integration

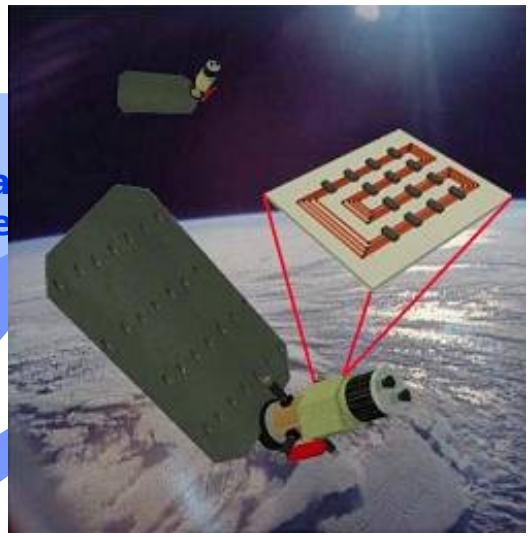
Impact: SENSING and HIGH SPEED IMAGE PROCESSING – Using Photonics

Quantum well, superlattice, quantum dot, nanotube IR detectors



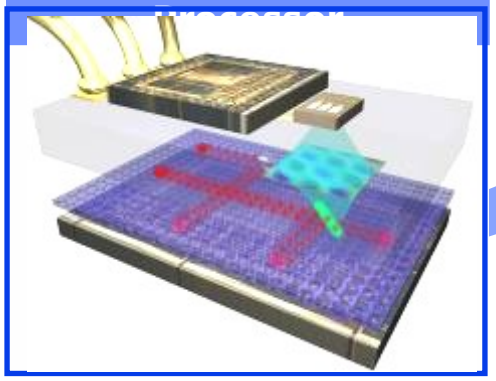
Optics | IRFPA | Visible FPA | A/D

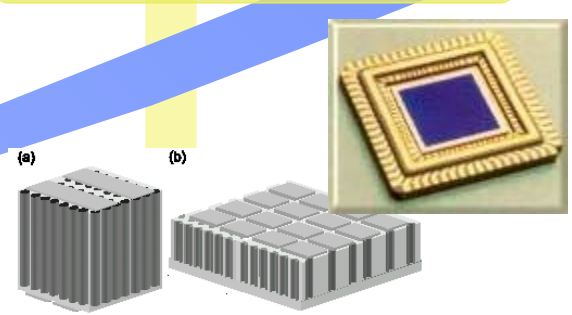
Ima
Proce



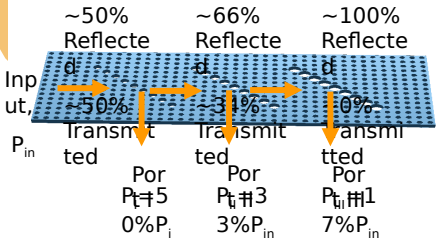
Quantum Device Technology
25 - nm Devices
Terascale Integration

Nanophotonics





PhC A/D converter



High Speed, Low Power Analog-to-Digital Converter

"Advanced signal processing components for infrared & THz imagery, smart munitions, target acquisition and satellite imagery."

Optoelectronics Components, Information Processing, High Density Memory

Quantum Computing w/ Optical Methods

AFOSR Type II QC Theme

Optical Memory/Storage & Image & Communications Processing

Woods (AFRL/SNHC HAFB)

Terahertz Sources & Detectors

Soref/Lorenzo (AFRL/SNHC HAFB)

Nelson (AFRL/SNDD WPAFB)

Nanophotonics & Nano-Probes

(Silicon Photonics)

Soref & Buchwald (AFRL/SNHC HAFB)

focus

Optoelectronics Information Processing & Optical Mem

Nanofabrication, 3-D Assembly, Modeling & Simulation Tools

Quantum Devices - Photonics: Nanotubes; Nanowires; Nano-particles; Q-Dots

Optical Components & Integrated Photonics

Vaccaro/Buchwald/Lorenzo (AFRL/SNHC HAFB)

Nelson (AFRL/SNDD WPAFB)

Congressional Adds

URI

1. DARPA/AFOSR DURINT 2001: Surface Modification (1)
2. FY03 MURI topic #12 Laboratory Instrumentation Design Research – Nano-probe Tools and Instruments (2)
3. FY04 MURI Topic: Nanophotonics & Plasmon Optics (2)

AFOSR, EOARD, AOARD

External Interactions (DARPA, AFRL, NSF, NRL, etc)

Core | URI | Other Core | Non-AFOSR | Lab Task

3D Negative-index PhC Lens for Sub-wavelength Imaging Applications

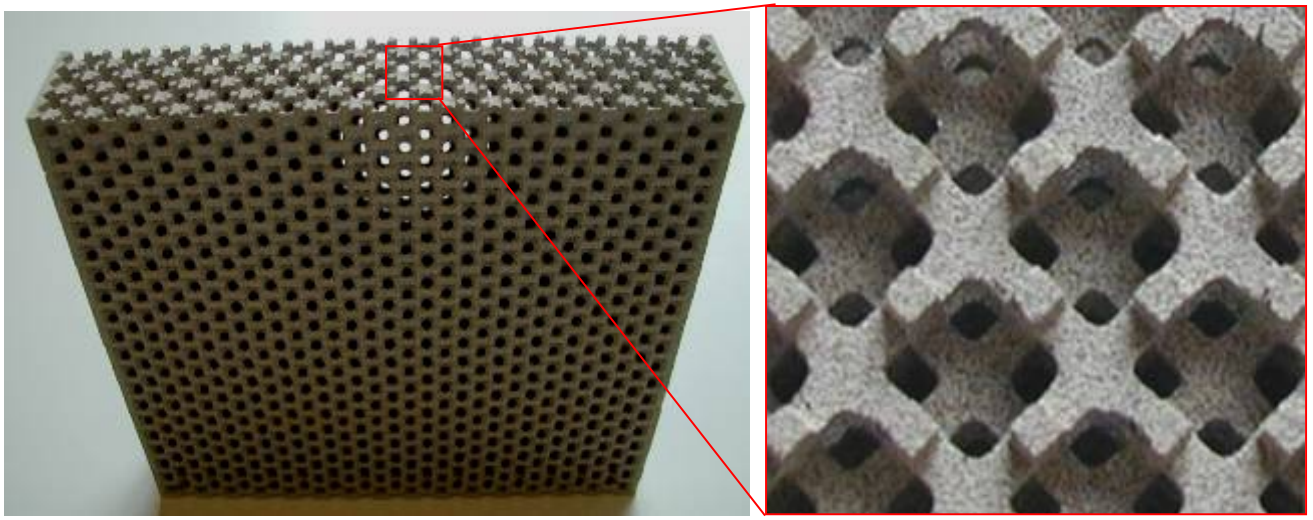


Fig. 1: 3D body-centered cubic photonic crystal for achieving negative refraction imaging.

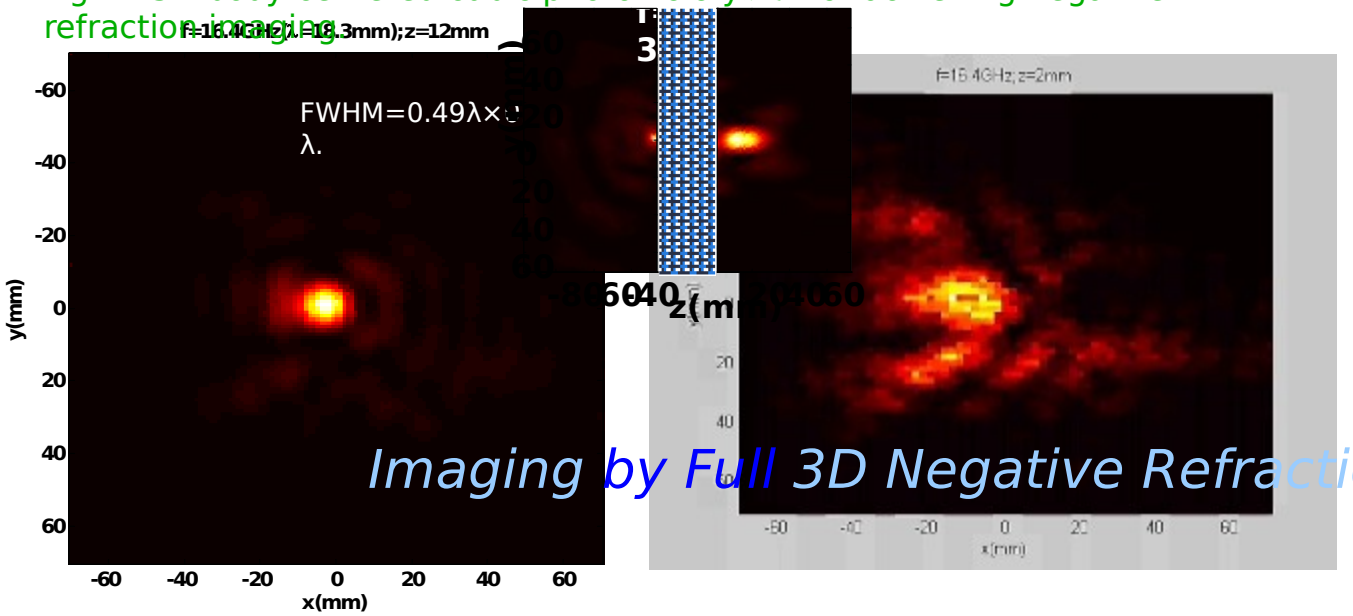


Fig. 2: Subwavelength image for a dipole is achieved. Mov. 1: Image is formed at 12mm away from the lens.

Prof. Prather, UDL

First time ever demonstration of a spherical negative refraction lens in the millimeter-wave wavelength region.

Recently fabricated a body-centered cubic lattice photonic crystal and used it to experimentally demonstrate imaging at millimeter-wave frequencies using full 3D negative refraction.

The realization of 3D photonic crystal lens is not only important for practical applications, but also significant for fundamental research since full 3D negative refraction, as a basic

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- Current initiatives and examples
- **Collaborations**
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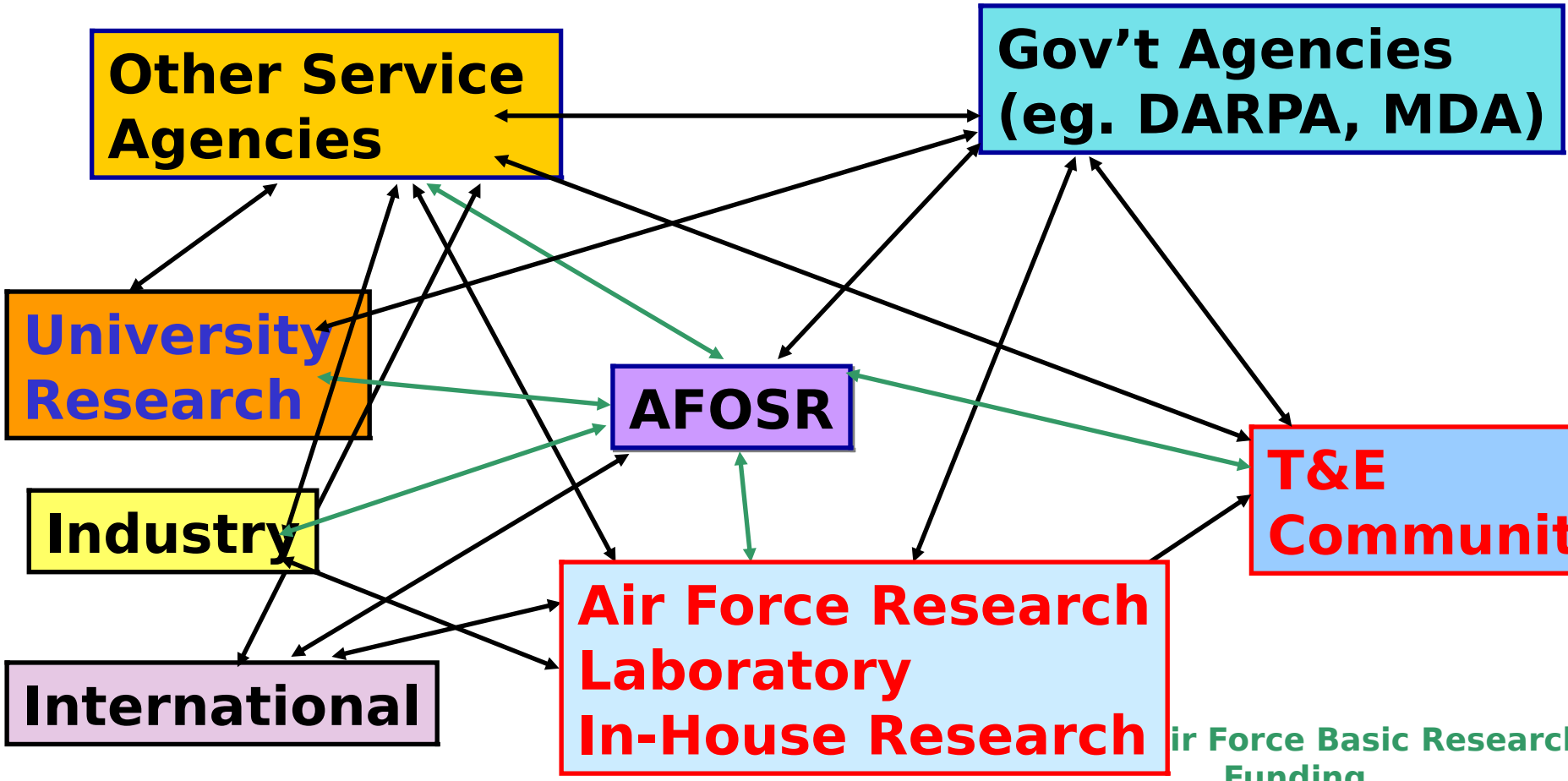
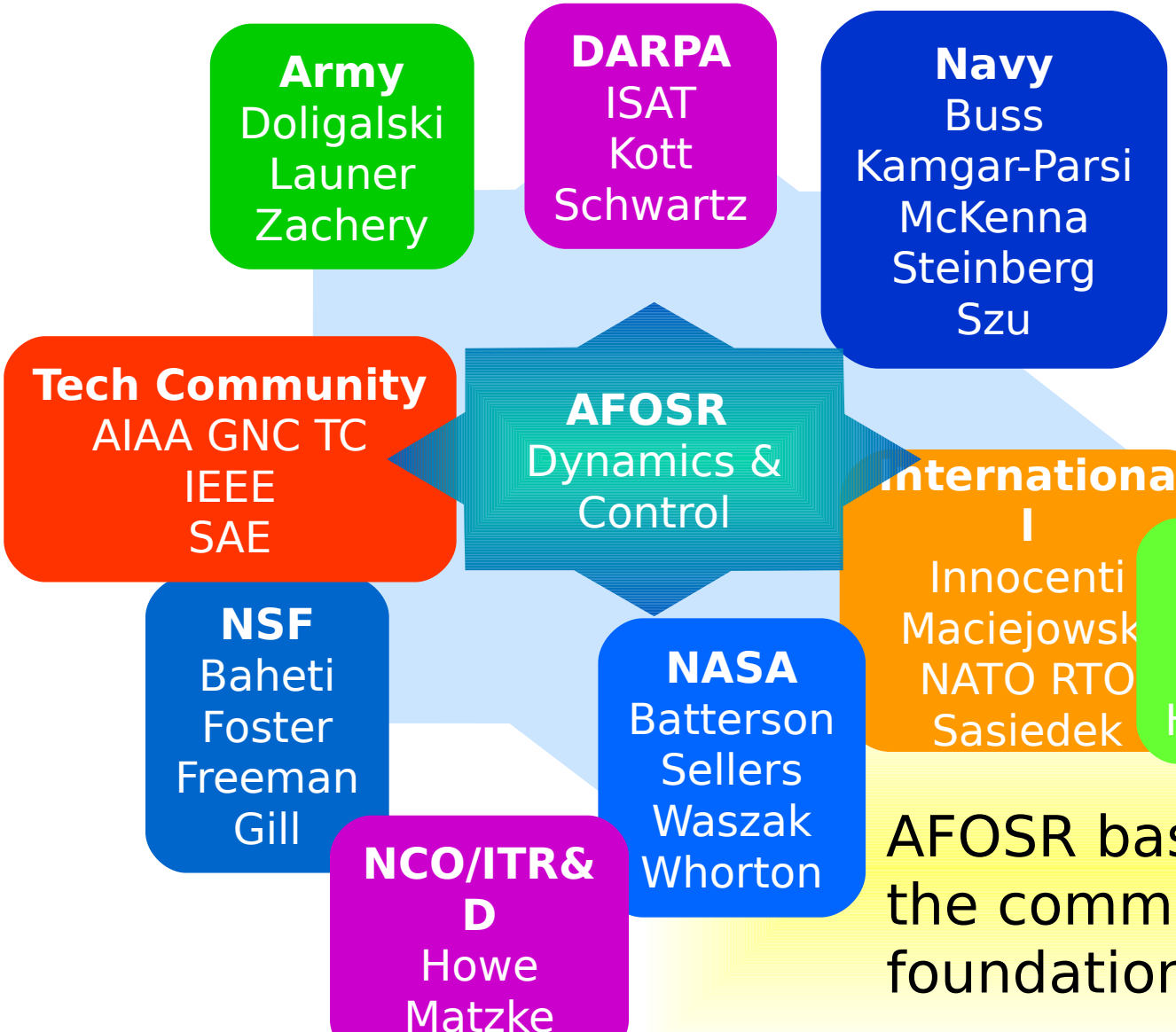
Research Collaboration



ir Force Basic Research Funding

Air Force In-House Resea

Dynamics & Control External Collaborations



AFOSR hosts sole program 100% dedicated to basic research in dynamics and control

AFOSR basic research is the community foundation

Air Force Biological Sciences

Agency Interactions

DARPA **— Biomimetics (stealthy sensors, camouflage); Biomaterials (biomagnetics, BMM); Biointerfacial Sciences (signaling pathways, MOLDICE)**

- ***Army*** **— Bioresponse Prediction (lasers); Biomimetics; Biomaterials (silk); Biointerfacial Sciences (bionanotechnology)**
- ***Navy*** **— Bioresponse Prediction (jet fuels, microwaves, lasers), Biomaterials (biomagnetics, biocomposites, silk, bionanotechnology)**
- ***DOE*** **— Bioresponse Prediction (nanomaterials); Bioenergy (biosolar hydrogen); Biointerfacial Sciences (biosensors)**
- ***DTRA*** **— Adaptive Bio-Mechanisms (hormesis); Biointerfacial Sciences (biosensors)**
- ***DIA & NASA*** **— Biointerfacial Sciences (biosensors)**

Biology Program Coordination

- **Program managers at ARO, AFOSR, ONR, and DARPA interact frequently with their DoD counterparts**
  - **to discuss new programs and transitions**
  - **to participate in proposal evaluations, kick-off meetings, program reviews (e.g. MURIs; Army's ICB; BRR; SERDP Working Group) and with other agencies**
- **Plan and implement interagency programs to share resources via OSTP/NSTC interagency work groups such as Metabolic Engineering (involving DoD, USDA, DOE, NIST, NSF, NIH, EPA< NASA, FDA, for example); Environmental Biotechnology; Microbe Project; Molecular Vaccines; Marine Biotechnology.**
- **Co-managing ~$65M of DARPA investment in FY06**
- **Transition OSR Core findings and MURI discoveries to DARPA**

Chemistry Program Coordination

- **Joint Technical Meetings**
  - Computational Chem. & Mat'ls Sci – DoD Coordination Mtg – March 05
  - Tri-Service Corrosion Meeting – November 2005
  - DoD Advanced Energetics Technology Interchange Meeting
  - Chem–Bio Defense Quarterly Tri-service Meeting
- **Joint Programs/Working Groups**
  - Joint Chem-Bio Defense Non-Medical Basic Research Program
  - Tri-service coordination on Power and Energy
  - MURI topic development, proposal evaluation
- Program Reviews
  - Participation in Division Reviews (e.g. – ARO Board of Visitors, NRL)
  - Attendance at Contractor's Meetings, MURI Reviews, etc.
- **Reliance Meetings**
  - Multiple reliance meetings each year for investment planning
- Collaboration
  - NRL-AFRL-USNA collaborations; AFOSR-ARO personnel transitions

University Centers of Excellence

- **Co-Funded by AFOSR, TD and University**
- **Extends the capabilities and scope of AFRL**
- **Opens up opportunity for continued focus on AF needs to a new generation of scientists**
- **Six Centers Funded:**
  - **Intelligent Information Systems Institute (IISI) - IF, Cornell U**
  - **Information Assurance Institute (IAI) - IF, Cornell U**
  - **Collaborative Center of Control Science, - VA, Ohio State U**
  - **Metals Engineering - ML - Ohio State U**
  - **Collaborative Center in Polymer Photonics - ML, U Akron**
  - **Center for Agile Autonomous Flight – MN, U Florida**

OUTLINE

- AFOSR Overview
- Current initiatives and examples
- Collaborations
- **Programs and processes**
- Summary

Grant Proposal Selection Process

- **Core Broad Area Agency Announcement (BAA) is open at all times to good ideas**

http://www.afosr.af.mil/

- **General Process**
  - **Researchers submit white papers to AFOSR program managers (Fall time frame)**
  - **Promising white papers are suggested for full proposals**
  - **Proposals are merit reviewed for *excellence* and *relevance***
  - **Individual grants are typically for three years**

Portfolio Goals and Considerations

- **Goals**
  - **Provide revolutionary scientific breakthroughs to maintain military air and space superiority**
  - **Avoid technological surprise**
  - **Build collaborations between AFRL and universities**
  - **Educate tomorrow's scientists and engineers**
- **Primary Considerations for grant selection**
  - **Technical excellence**
  - **Relevance to goals**
  - **Potential for revolutionary impact**
  - **Potential to influence scientific research priorities**

Small Business Technology Transfer (STTR) Program

- **The STTR Program provides up to $850,000 in early-stage R&D funding directly to small companies working cooperatively with researchers at universities and other research institutions (http://www.acq.osd.mil/sadbu/sbir/solicitations/sttr06/preface06.htm)**
  - **Company must be a U.S. For-profit small business, 500 or less employees; No size limit on research institution**
  - **Research institution must be a U.S. college or university, FFRDC or non-profit research inst.**
  - **The principal investigator may be employed at the small business or research institution**
- **Air Force Has 35 STTR Topics in FY06 (see list at http://www.dodsbir.net/solicitation/sttr06/af06.htm)**
  - **February 1, 2006: Solicitation was issued for public release**
  - **March 15, 2006: DoD began accepting proposals**
  - **April 14, 2006: Deadline for receipt of proposals**
  - **August 15, 2006: Contracts Awarded (approximately)**

Impediments to Transition

- **Intellectual Property Agreements required for STTR**
- **Lack of 6.2/6.3/6.4 funds**
- **STTR with Government partner requires commercial test agreement (Gov’t agency must be paid directly by contractor)**

Partnership for Research Excellence and Transitions (PRET)

- **Up to five years duration**
- **Typically $0.5-1M/year (can be over $2M)**
- **Prime is one or more universities**
- **Must have at least one industrial partner to ensure transition of research; industry gets funding as subcontractor to university**
- **Current PRETs**
  - **Advanced Concepts in Space Situational Awareness**
  - **Information Fusion for Command and Control**
  - **Information Fusion for Image Analysis**
  - **Information Fusion Support for Natural and Man-made Disasters**
  - **Homeostatic & Circadian Regulation of Wakefulness**

AF Young Investigator Program

(New for FY-07)

- **Support young scientists/engineers in AF relevant areas**
  - **Enhance early career professional development**
  - **Promote innovative research**
  - **Increase opportunities to recognize AF challenges**

- **Awards and Submission features**
  - **3-year renewable awards $100K/year (minimum)**
  - **15 new awards each year (45 or more steady state)**
  - **Proposal due 4:00 p.m. EDT, Thursday, 20 July 2006**
  - **BAA can be found at http://www.afosr.af.mil/pages/oppts/afrfund.htm# Research**

SUMMARY

- Basic research generally cannot be roadmapped
- AFOSR is adapting to the GWOT with substantive initiatives
- Basic research leads to discovery

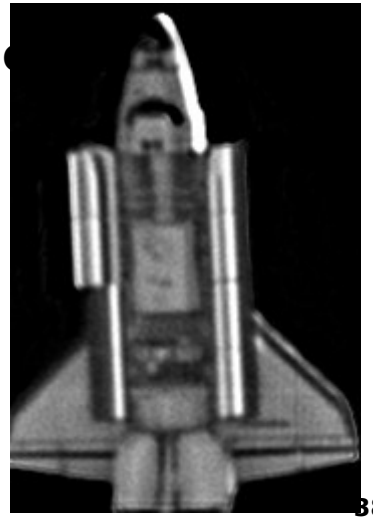
- Discovery requires innovation/application/further development to become useful

- STTR is a common transition path
- Other AFRL TDs are another common path, when funds are available
- AFOSR is open to transition/transfer ideas— **we need your help to identify paths to transition/transfer**

BACK-UPS

Recent Technology Transitions

- **Laminar Flow Control for Reduced Drag (university to AFRL/VA, DARPA, and industry) – reduced aircraft fuel consumption**
- **Fiber-Optic Sensor for Total Lifetime Monitoring of Polymer Matrix Composite Materials (university to industry, new company formed) – improved aircraft maintenance**
- **Real-time Scintillation Prediction Capability (AFRL/VS to Air Force Weather Agency) – more reliable satellite communications**
- **Nanowire Technology for Future High Performan Lightweight Electronics (university to industry)**
- **Coatings Deposition Process for MEMS Devices Prevent Friction and Wear (AFRL/ML to industry) – reduced maintenance**
- **Self Healing Composites (university to industry) – greater reliability, reduced maintenance**



Recent Scientific Breakthroughs Supported by AFOSR

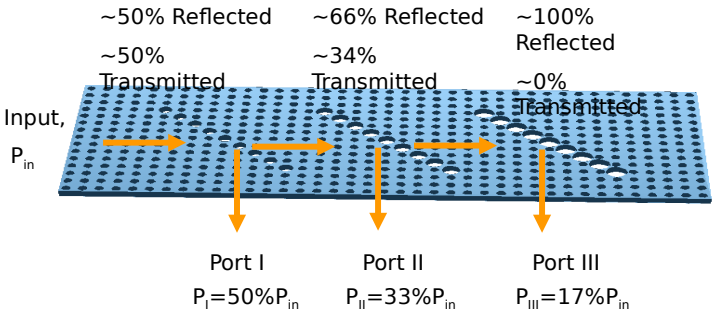
- **Spintronics:** Studying electron spin coherence, ultrafast electronic spin polarizers, and electronic spin manipulation • Implications for all aspects of information processing technology
- **Left-Handed Materials:** Developing magnetic composites negative indices of refraction • Wide range of potential applications (antenna, microwave devices, shielding)
- **Interference Suppression:** Developed conformal antenna circuitry for GPS interference suppression • Transitioned to UAV Special Projects Office (SPO)
- **Polynitrogen Chemistry:** Computational methods used to aid synthesis of new all-nitrogen compounds • First new all-nitrogen species, N_5^+, in over 100 years • Studying reactivity and compatibility of compounds
- **Electric Oxygen Iodine Laser (EOIL):** Developing a new class of electric hybrid lasers • Lasers retain benefits of Chemical Oxygen Iodine Laser (high power, good beam quality, etc) while eliminating reliance on potentially hazardous chemicals
- **Electromagnetics:** Developed Incremental Length Diffraction Coefficients method to predict radar cross sections • Transitioned to Industry

STTR Phase II : Photonic Bandgap Devices
First Experimental Demonstration of
All optical A/D Converters Using Photonic Crystals

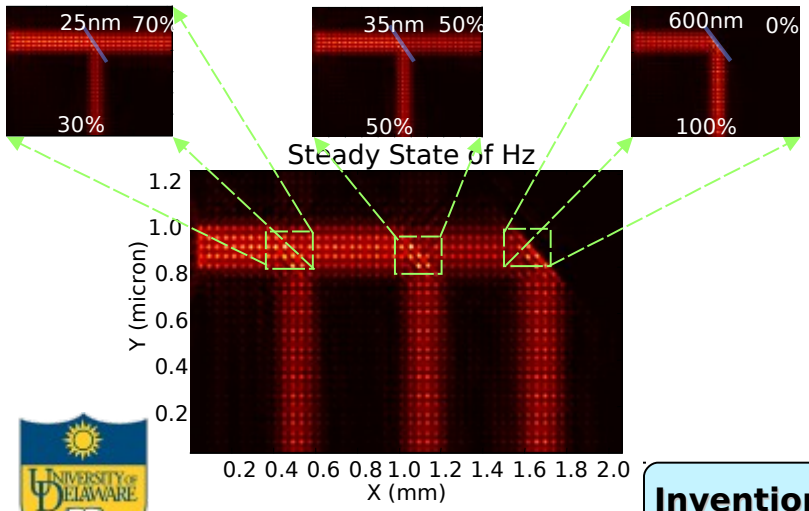
Goal: Define and develop a new paradigm for engineering global properties of photonic crystals that combines design, simulation, fabrication and characterization.

Impact:
- Photonic crystal (PhC) dispersion based devices including ADC will provide the basic building blocks to transfer PhC technology from research labs to commercial market.
- Develop PhC devices that are immune to fabrication tolerances.

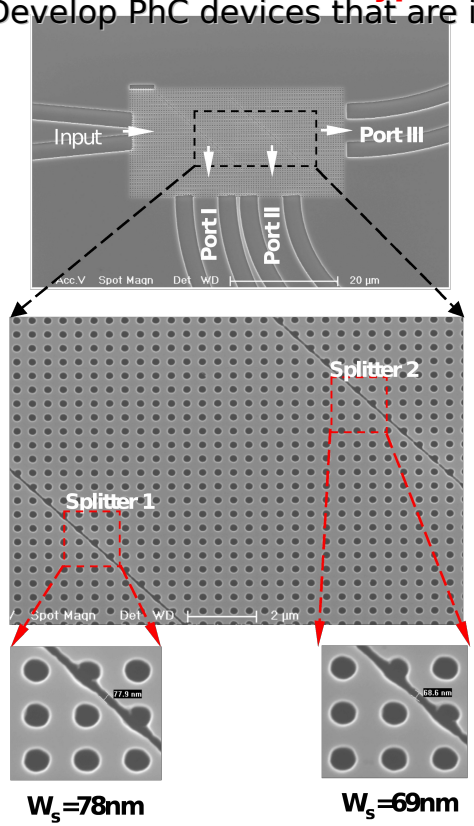
Two- bit Optical A/D design



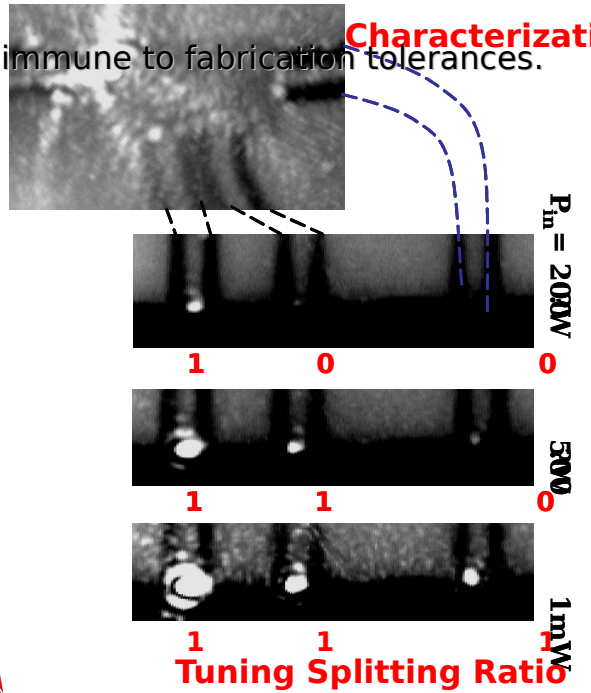
Simulation



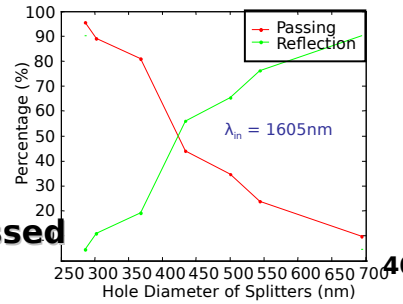
Fabricated Prototype



Characterization



Tuning Splitting Ratio



Invention Report is currently being processed

Co-PI: D. Prather **AFOSR Contract** FA9550-04-C-0062 **Start Date**: Jul/04 - **End Date**: Jul/08 **PI**: A. Sharkawy

Example #1 STTR Topic

- **TITLE: <u>Quantitative Model of Human Dynamic Attention Allocation</u>**
- **OBJECTIVE: Develop quantitative model(s) of attention allocation in dynamically complex multi-modal task environments**
- **Key model requirements are:**
  - **Model must capture the timing and spatial parameters of dynamic information structures produced by multiple information sources in complex task environments, and**
  - **Model must characterize attentional expenditure patterns related to the spatio-temporal characteristics of dynamic information flow**
- **PHASE I:**
  - **Develop an innovative approach to the problem**
  - **Provide a prototype(s) model based on this approach**
  - **Demonstrate that prototype meets the key model requirements**

Example #2 STTR Topic

- **TITLE: Nano-scale Optical Components**
- **OBJECTIVE: Fabricate optical components employing subwavelength structures exhibiting particular polarizing, reflecting, and transmitting properties in the ultra-violet to terahertz spectral regions**
- **PHASE I: Demonstrate feasibility of optical devices with nano-scale structures for the manipulation of light in UV to THz spectral regions that exhibit particular optical properties such as polarization, reflection, and transmission. Identify application, integration and performance parameters**
- **PHASE II: Build upon Phase I work and demonstrate a system of one or more variations of the components and implementation of a working prototype. Perform appropriate analysis and modeling, design the materials and other elements, fabricate the device and test its performance. Address the issues of integration into an optical system requiring the functionality provided by the**

International Highlights

EOARD

AOARD

Hypersonics: Russia

- Leveraging Russian Expertise (Boundary Layer Control, Plasma Fuel Injection, Heat Flux Control, etc.)
- Technology is Transitioning

Hall Effect Thruster (HET): Russia, Spain

- HETs Provide Highly Efficient Spacecraft Propulsion (Increased Payload/Decreased Cost)
- Investigating How to Cluster Multiple HETs for Increased Power

Damping Coatings: Ukraine

- Seeking to Overcome High Cycle Fatigue Effects on Titanium in Air Force Fighter Engines
- Investigating Layering Materials on

Hyshot In-flight Scramjet Test – Australia

- Leveraged Data from First In-flight Supersonic Scramjet Com. Test – (Mach 7.5)

Ionospheric Scintillation Data – Taiwan

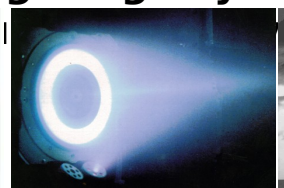
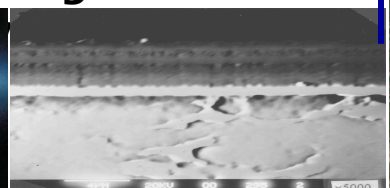
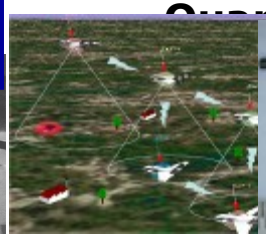
- Studying low-latitude events that interfere with Communications

MicroTubine Research – Japan

- Developing Lunch-Box size power sources (100W), 10 mm Rotors

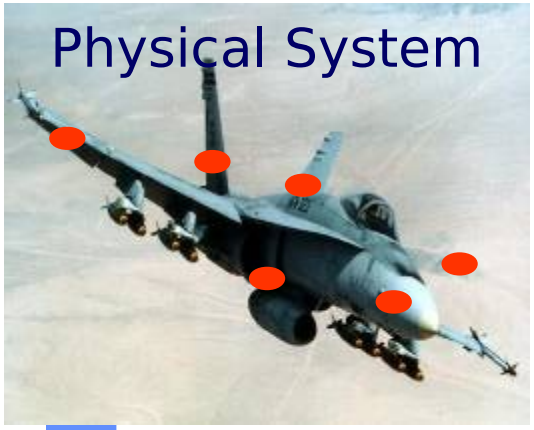
Nanoscience Initiatives – Taiwan & Korea

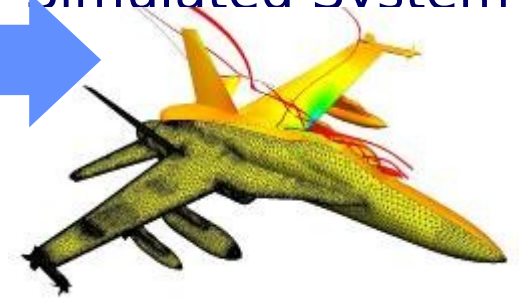
- Leveraging Asia's $1B Nano-science investment

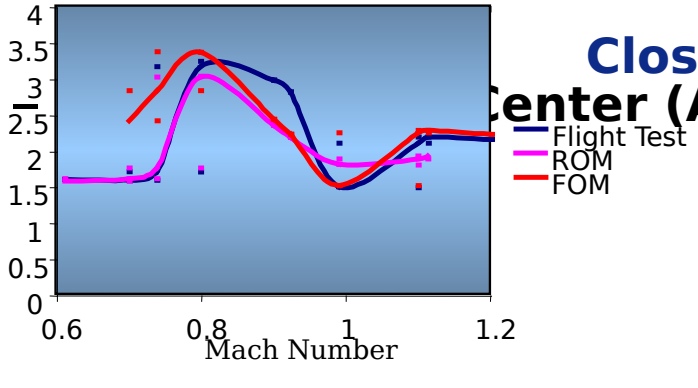




Test and Evaluation

- **$2.4M AFOSR program focuses top university and industry scientists on reducing costs and increasing effectiveness of $multi-billion AF T&E program**
- **Multiple AFOSR program managers involved**
- **Program identified and evaluated collaboratively with AF T&E Centers**
  - **Arnold Engineering Development Center (AEDC)**
  - **Air Force Flight Test Center**
  - **enter (AAC)**







Closing the Gap on Real Time Prediction of I

Full-Order Model (FOM)	Reduced-Order Model (ROM
10 minutes CPU on a 160-processor Linux Cluster	5 seconds CPU on the same 160-processor Linux Cluste

FResH
Fundamental Research in Hypersonics

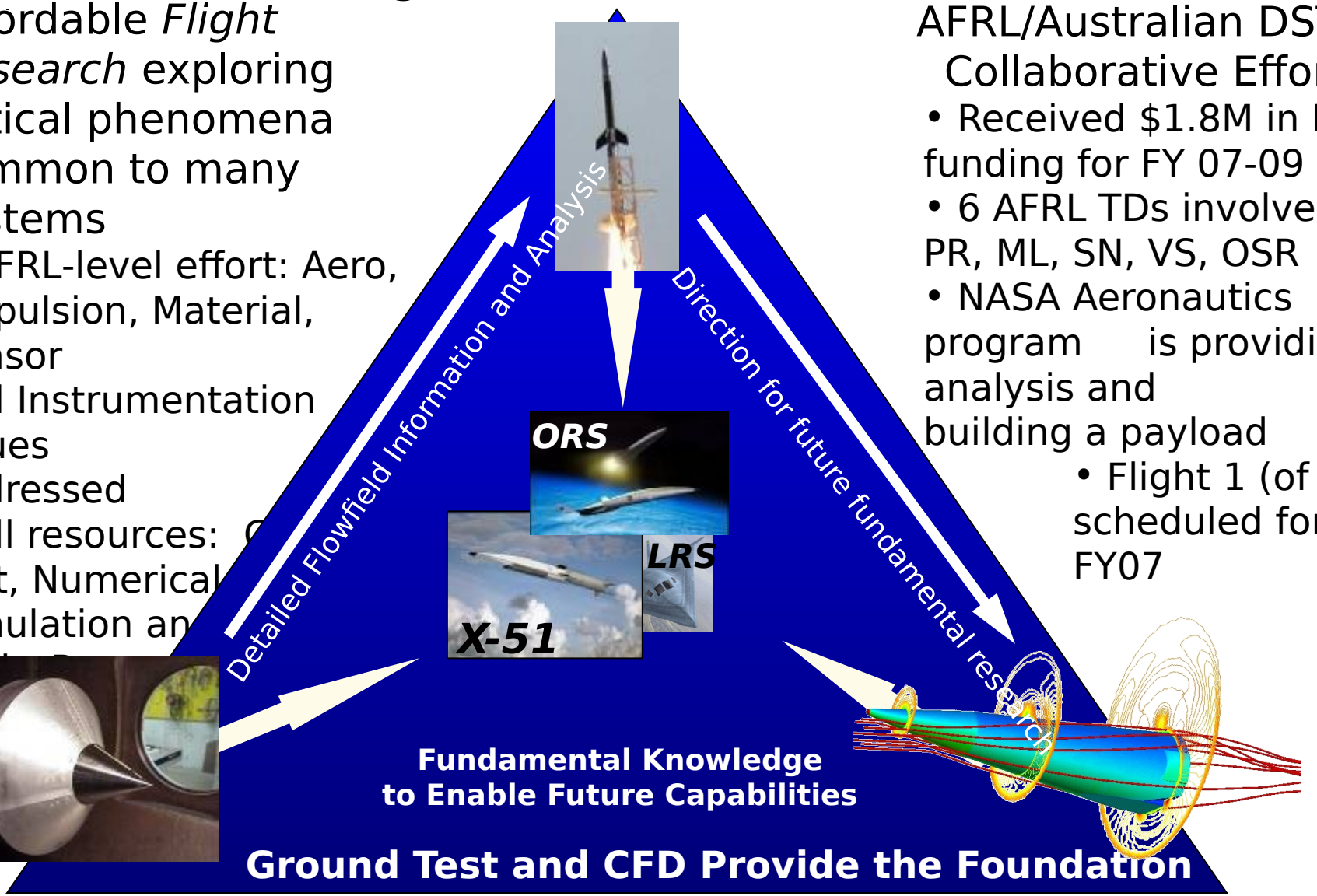
Flight Research Provides Focus

Affordable *Flight Research* exploring critical phenomena common to many systems

- AFRL-level effort: Aero, Propulsion, Material, Sensor and Instrumentation issues addressed
- All resources: G Test, Numerical Simulation an

AFRL/Australian DSTO Collaborative Effort

- Received $1.8M in ICR&D funding for FY 07-09
- 6 AFRL TDs involved: VA PR, ML, SN, VS, OSR
- NASA Aeronautics program is providing analysis and building a payload
- Flight 1 (of 10) scheduled for Late FY07

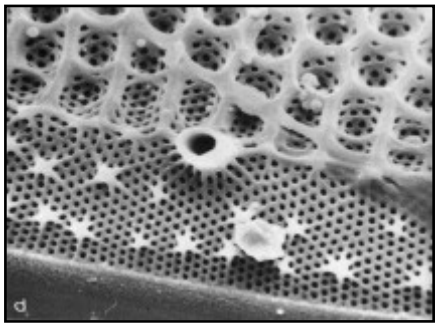


NRC Information Science and Technology Study

- **Networks & Communications:** Decision theory, communication theory and design principles that enable large scale, dynamic networks
- **Software & Security:** Capability to analyze the composability, evolvability, scalability, and security of large software intensive systems
- **Information Management & Process Integration:** Capability for active interrogation and instantaneous, synchronized exploitation of actionable information
- **Human-System Interactions:** Augmented human capability produced via training and hybrid systems and the formal models (computational and mathematical) for analyses in all phases of operation: anticipate, observe & orient, decide, and act

University Research Initiative Program (FY2005)

- Multidisciplinary University Research Initiative ($54.6M): 70 grants at 40 institutions
  - Grant size will increase in FY2007
- Defense University Research Instrumentation Program ($15.8M): 70 grants at 53 institutions
- Education ($34.3M)
  - National Defense Science and Engineering Graduate (NDSEG) Fellowships: 430 PhD-track students/year
  - Awards to Stimulate and Support Undergraduate Research Experience (ASSURE): ~500 students/year
  - PECASE: 2 per year



University Research Initiative (URI) Program Moved From OSD to AF in FY 2004